Sense Making: Biases and Support Solutions

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Analysts base their hypotheses concerning terrorist groups and terrorist attacks generally on large amounts of information, which may be uncertain, inconsistent and/or incomplete. The present paper addresses the questions of how an analyst constructs a causal scenario, which biases occur and how this intelligence process can be supported. In the first part a model is presented that describes the subsequent steps in the analysis process. Several biases may negatively affect the quality of the analysis process. These are described in the second part of the paper. Subsequently, an experiment is described in which we manipulated the presentation of information: in a time line, a relation scheme or unstructured. In general, the results show that people generate fewer motives in the unstructured task condition and that expectations increase probability assessment of related hypotheses. The last part of the paper presents support concepts which aid analysts to critically think about their own analysis: To what extent is a hypothesis anchored in the data at hand, how to explain data not in line with the hypothesis and which other hypotheses would be possible as well? Supporting analysts in critical thinking not only improves situation awareness and decision making, but allows for better communication with others as well.

1.0 INTRODUCTION

Intelligence services are more often confronted with mistakes such as the use of unsubstantial evidence, unrecognised threat and poor exchange of information. Some of these problems can be solved by technical solutions, such information exchange or integration of information, but for others human information processing needs to be supported. This not only involves the availability of information but also the quality of the analysis. The fist part of the paper addresses the way information is analysed. In the second part of the paper several biases are described. The third part describes a recent experiment on the effect of visualisation on sense-making and the fourth part proposes some ways to support intelligence analysis.

1.1 The analysis process

Recently, Pirolli & Card (2005) presented a scheme that describes subsequent steps in an intelligence process (see Figure 1). Basically, two different loops can be distinguished: a foraging loop aimed at the gathering, selecting and evaluation of information and a sense making loop aimed at finding the meaning of the information.

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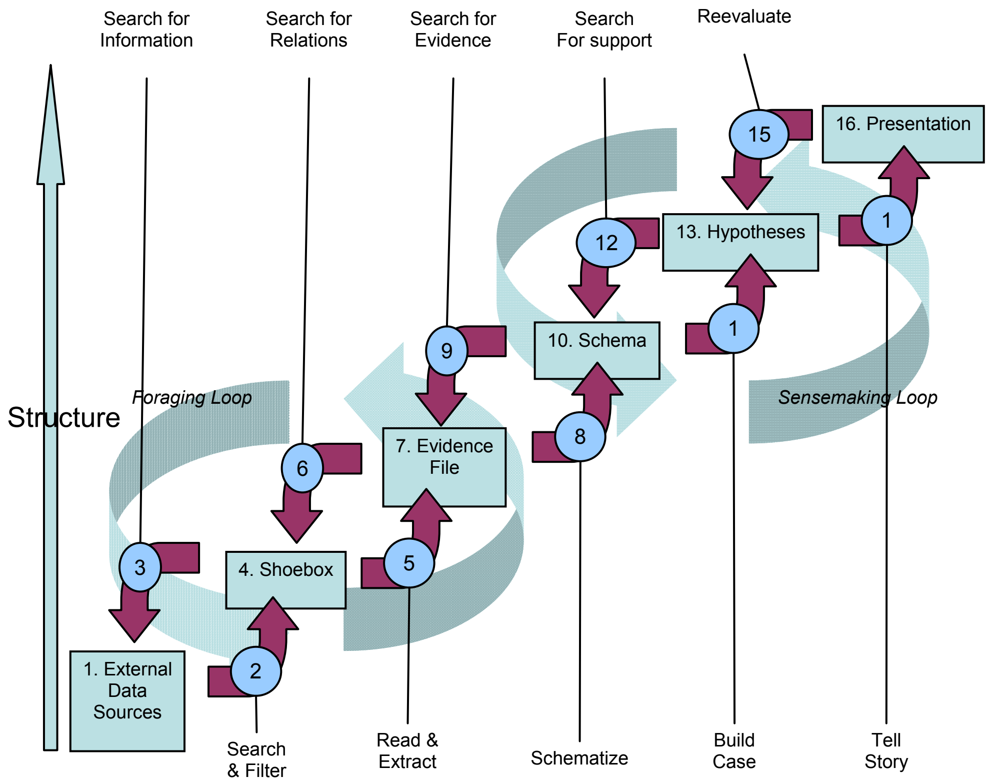

Figure 1: model of intelligence process (Pirolli & Card, 2005)

The squares represent how data is transformed and the circles indicate the various steps in the process. Data undergo the following transformations: the external data sources (left in Figure 1) are the raw data, mainly text. From these data sources, information is selected that is relevant for further processing (shoebox). The evidence file contains pieces of evidence that have been selected from the shoebox. These pieces of evidence are subsequently visualised in some kind of scheme, which can take on different forms, such as a time line or a relation scheme. On the basis of this scheme, interpretations can be made in order to build up a scenario. Hypotheses are tentative conclusions, founded by arguments. Ultimately a kind of presentation will be given to answer the question posed to the analyst.

Two kinds of processes can be distinguished: bottom-up and top-down (indicated by the circles in Figure 1). The bottom-up processes move from left to right, and include operations like searching and filtering of information, extraction and schematization. Top-down processes, on the other hand, move from right to left and are mainly used to find support for assumptions or conclusions. A new hypothesis, for example, may give reason to go back to the raw data in order to check whether the hypothesis at hand fits with the data.

1.2 Hypotheses and scenarios

Analysts who are trying to make sense of a set of information, strive for a story or scenario that is logical, consistent and plausible (Pennington & Hastie, 1993). The resulting scenario is partly based on the facts available, but inevitably interpretations and inferences are made as well. These interpretations and inferences are based on general world knowledge and domain-specific knowledge. Pennington and Hastie (1993) showed that, due to this mechanism, jurors can infer totally different verdicts on the basis of the very same information. As personal beliefs affect the interpretation of information and the way missing data is filled in, jurors come up with different stories and, as a consequence, different verdicts.

The human information processing system has limited capacity: working memory can only manage one hypothesis at a time. Research has indicated that persons generate only a small proportion of scenarios possible, when they are required to make sense of a set of data (Dougherty, et al., 1997). One starts with a limited set of possible scenarios, which is reduced as soon as possible, by means of consistency checks. If a particular hypothesis is generated, its consistency is checked against the data available, and if it seems unlikely, it is eliminated from the set.

A complete scenario is difficult to test, and for that reason it is fractioned into smaller units, the hypotheses. These hypotheses mostly concern central statements in the scenario, which can be checked against the data available. The probability of a hypothesis is determined by comparing it to alternative hypotheses. It has been shown that individuals are more realistic about the likelihood of a hypothesis when they are forced to think of an alternative hypothesis. Thinking about the underpinning of a particular hypothesis, inadvertently leads to tunnel vision. Considering alternative hypotheses breaks through this inertia (Koehler, 1991).

2.0 EXPERIENCE AND BIASES IN INTELLIGENCE ANALYSIS

As mentioned above, a scenario results from an interpretation of data available. As such, it contains subjective elements resulting from previous experience with similar cases, general world knowledge and individual beliefs. In the present chapter, I will discuss the influence of experience and some biases on intelligence analysis.

2.1 Influence of experience

Due to years of experience, experts have built up patterns that represent the most important features of the task. Even though it has been suggested that expertise also depends on personal abilities, it has been shown that expertise is mainly defined by these domain-specific schemes (Ericsson & Lehmann, 1996). The content of these patterns depends on the specific domain in which the expertise had been built up. Physicians, for example, built up scripts that represent the relations between symptoms, context and disease (Boshuizen & Schmidt, 1992), whereas market intelligence analysts have developed schemes representing characteristics of players, developments and opportunities (Pirolli & Card, 2005).

Schemes enable a quick structuring of huge amounts of information, in order to make sense of the situation. This doesn’t mean that it is passive pattern recognition. In intelligence analysis there is a continuous interplay between data available and knowledge already stored in memory: data may trigger knowledge, whereas knowledge directs the way information is gathered and interpreted.

The extent to which experience positively contributes to the intelligence process, is dependent on the learning environment (Hogarth, 2001). An important mechanism that causes incorrect knowledge to be built up is that persons almost exclusively learn from what they see, and ignore content that cannot be seen. In intelligence analysis, for example, the focus is often on evidence that provides an underpinning of the hypothesis at hand, whereas data that might falsify the hypothesis is ignored. Naturally, individuals do not tend to falsify their hypothesis, but base their knowledge on positive observations. An implication of this tendency is that analysts should be supported in testing their hypothesis critically.

As far as hypothesis generation is concerned, Weber, et al. (1993) showed that experts more often related a hypothesis to own experience. In our own experiment with crime analysts we found no relationship between years of experience and the analysis process (Kerstholt & Eikelboom, submitted). Even though it was not systematically investigated, the results suggested that specific experiences with a case triggered a particular hypothesis. Part of the analysts, for example, mentioned a ‘lover boy’ scenario as an explanation for the disappearance of a young woman and mostly referred to their own experience with a similar case.

In all, our results suggested that years of experience did not affect the analysis process, only domain specific knowledge.

2.2 Biases and expectations

Knowledge or beliefs create a context against which new evidence is interpreted. An illustration of this effect is shown in Figure 2.

12

A 13 C

14

Figure 2: Illustration of the context effect

The symbol in the middle can either be seen as a number (13) or as a letter (B). The symbol is somewhat ambiguous and this ambiguity is solved by taking the context into account. If the series is read from top to bottom, the symbol is interpreted as 13, but if it is read from left to right the symbol is interpreted as a 'B' (Risinger, et al., 2002). Context therefore induces an expectation with regard to the interpretation of an ambiguous stimulus with the result that ones sees what one expects to see.

Particularly in juror decision making numerous studies have investigated the effect of extra-legal factors, such as the defendant's status (Bornstein, 1994), race (Foley, Adams & Goodson, 1996) or pretrial publicity (Otto, Penrod & Dexter, 1994). As noted by Bornstein (1994), many extra-legal factors exert their effect by drawing on juror's prior beliefs. A juror might, for example, belief that a defendant with a particular background or race is more likely to commit a crime. Often this belief will not have any diagnostic value and it will therefore affect the judgment negatively. An extra-legal factor could also work as a scheme or framework to which new evidence is related. An opening statement, for example, creates such a schema (Spiecker & Worthington (2003), but also a hypothesis that is tentatively favored as the trial progresses. Carlson and Russo (2001) showed that when a juror has such a tentatively favored hypothesis, new evidence is somewhat distorted in order to fit the hypothesis.

In an experiment with crime analysts an expectation was induced by presenting analysts a particular interpretation of the case, before they started with their analysis (Kerstholt & Eikelboom, submitted). Analysts who had seen the prior interpretation considered the suggested scenario more likely than analysts who had not received it. This result held for both inexperienced and experienced analysts. As analysts are generally well aware of potential biases due to prior beliefs, it can be concluded that awareness alone is not sufficient to eliminate biased interpretation.

3.0 INFORMATION PRESENTATION

Support for intelligence analysis is mostly geared towards filtering and structuring huge amounts of information. By means of visualisation of relationships between various data, patterns can be detected more easily which reduces workload of the analyst (Xiang, et al., 2005). However, data can be visualised in different ways, for example by a timeline or relation scheme, which might differentially affect the sense making process of the analyst.

In order to investigate whether this is the case, we have conducted an experiment in which we presented participants with two visualisations of the same data: a timeline and a relation scheme and we compared both visualisations with an unstructured way of information presentation. We expected that participants would generate more hypotheses in the unstructured information presentation condition, as there would be no directing effect of the visualisation.

3.1 Design of the experiment

Forty-five participants (students) were required to generate explanations for the disappearance of a young woman. The woman came from a very religious family and it was known that her father was opposed to her relationship with a foreign man. Participants received 25 witness statements and were required to generate as many explanations for the disappearance as possible.

The witness statements could be presented in three different ways: 1) by means of a time line, meaning that all events and related witness statements were sorted by time; 2) relation scheme, showing all persons involved and their mutual relationship; 3) unstructured, meaning that all witness statements were presented in a random order. The different visualisations were presented on a computer screen and by clicking on a related button the underlying witness statement could be requested. In order to compel participants to think about the most relevant information, they could only request 80% of the statements available.

In addition to visualisation we also manipulated prior expectations. Half of the participants received an interpretation of the case before they did the task, while the other half did not have this interpretation. This interpretation suggested that the father had played an active role in the disappearance because he resented his daughter's relationship with a foreign man. We registered what information was requested, the number and kind of hypotheses generated, and probability assessments.

3.2 Results

Two different aspects could be distinguished in the hypotheses generated: the person involved and a motive. A possibility was, for example, that the woman had left on her own account, and motives could be that she wanted to escape from her father's pressure, that she was abused by her boy friend, that she was pregnant etc. Participants generated on average 4.9 (sd=2.0) persons or events that could be responsible for the disappearance of the woman and 5.7 motives (sd=2.3). There was a marginally significant interaction between presentation mode and kind of response, that is, persons or motives ($F(2,32)=3.18$, $p=.06$, see Figure 3). Univariate analysis showed that the number of motives differed across presentation conditions ($F(2,32)=3,56$, $p<.05$) and not the number of persons or events ($F92,32)=1.22$), $p>.1$). In the unstructured task condition, significantly fewer motives were mentioned than in the relation scheme and time line condition. As far as number of different persons was concerned, no differences were found. There was no effect of expectation ($F1,32)<1$).

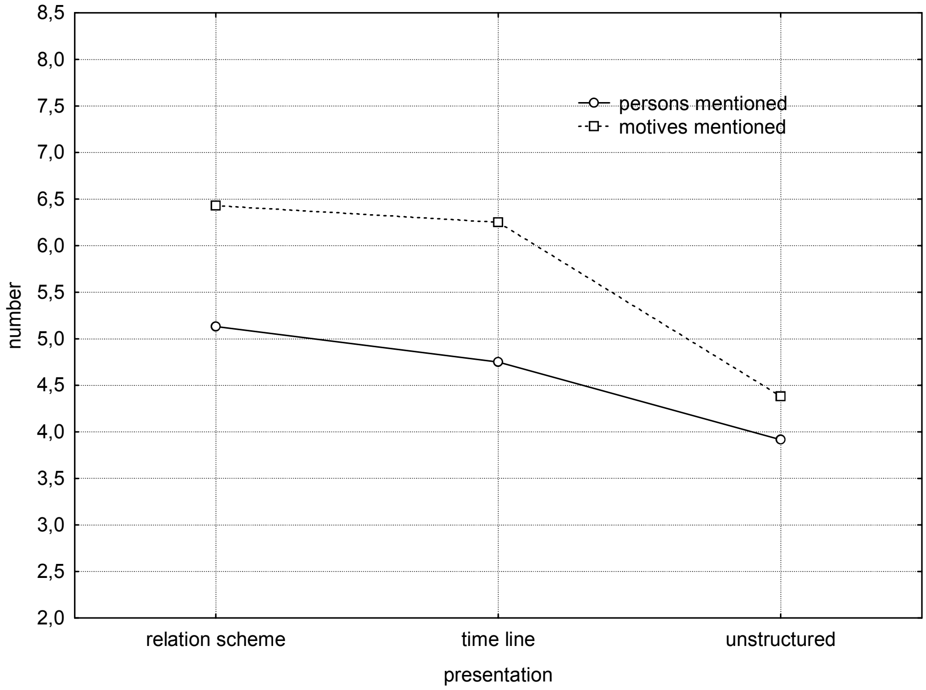

Figure 3: Number of hypotheses generated in all experimental conditions

Participants in the expectation condition considered the 'father scenario' more probable than participants who had not received a prior interpretation (.39 versus .57, $F(1,41)=6.43$, $p<.05$). The friend-scenario was marginally significant across expectation conditions ($F(1,41)=3.60$, $p=.06$). In the expectation condition, the possibility that her boy friend played a central role in the disappearance of the woman was considered higher than in the non-expectation condition (.51 versus .40). The self-scenario (she left on own account) was considered equally likely in both expectation condition ($F(1,41)<1$). Presentation mode did not affect probability assessments.

3.3 Discussion

We predicted that more hypotheses would be generated in the unstructured condition as there would be no influence of data visualisation into a particular direction. This prediction was not supported by the data. We made a distinction between the number of different persons or events that could be responsible for the disappearance and the motives that were mentioned. In the unstructured task condition significantly fewer motives were mentioned than in the time line and relation scheme condition.

A possible explanation for this effect is the increased workload in the unstructured task condition, as a representation needed to be built up from scratch. In the time line and relation scheme condition a representation was given, and participants could solely focus on hypothesis generation. In these conditions, participants generated significantly more motives than persons, whereas participants in the unstructured task condition generated approximately one motive per person or event. In the unstructured task condition participants were therefore less creative in generating possible explanations than in the other task conditions.

Expectations did not affect hypothesis generation, but only probability assessment of the hypothesis that was suggested in the prior interpretation. Participants who had received the prior interpretation gave a higher probability assessment to this hypothesis than participants who had not received a prior interpretation. This effect was independent of the way the information was presented.

The only unexpected effect was the marginally significant interaction between probability assessment of the 'friend-scenario' and expectation. The prior interpretation only concerned the father, but the friend-scenario was considered more likely in the expectation condition, as well. In the expectation manipulation it was suggested that the father had done something to his daughter because he could not accept her relationship with a foreign man. Possibly, participants thought of more extreme motives after hearing this interpretation which also increased the probability of the 'friend' scenario.

To summarise, participants seem to be less creative in generating possible reasons when information is presented unstructured. Prior interpretations do, on the other hand, not affect the number of explanations generated. The second conclusion is that expectations have an effect on probability assessment. A hypothesis that agrees with a prior interpretation receives a higher probability score.

4.0 SUPPORT SOLUTIONS

One of the main threats to biased information processing concerns the influence of prior beliefs. Due to these beliefs information is selectively gathered, it is interpreted in the direction of the belief, and information may even be distorted in light of a currently held belief. Such a set of beliefs has also been called a mindset and as indicated by Heuer (1999) they are neither bad nor good. They are simply unavoidable. It is not possible to process a large amount of information without knowledge of what to expect, what is important and how things are related. Over and above, even if analysts would be aware of these mind-sets, it would presumably not eliminate flawed judgements. In order to achieve a more objective assessment, essential assumptions underlying a causal scenario need to be made explicit, in order to allow for critical tests. In other words, what is needed is that analysts are supported in meta-cognitive strategies that enable them to critically evaluate their own assessment (Cohen et al., 1996; Hogarth, 2001).

As far as the generation of hypotheses is considered, it is recommendable to always think of an alternative hypothesis, as this will make the assessment of the main hypothesis more realistic (Koehler, 1991). An analyst can be supported in generating alternative hypotheses by showing patterns in the data that may point to a particular hypothesis. Support could be provided by providing quantitative data such as frequency of contact between persons involved, or by allowing search possibilities such as common ground between two persons (they may share, for example, the same garage or go to the same bar). Searching for patterns and relationships in data is a topic in which computers clearly outperform humans, as computational load is high.

In testing a hypothesis, research indicates that people tend to only look for confirming evidence and are quite reluctant to switch to an alternative hypothesis. In this phase of the analysis process people should be supported in critically relate the hypothesis stated to the data at hand. First, it could be visualised how the hypothesis is anchored in the data: which data support the hypothesis and which data don't? Second, people could be made aware of unknown parts of the scenario. One of the scenarios we used in our study on crime analysis, for example, concerned trade in women. Information was provided about persons and property, but not about the financial flow. A semantic network indicating all aspects involved in trade in women could have made this lack of information visible, allowing the analyst to be aware of missing information. Third, analysts could be made aware of critical assumptions underlying their hypothesis by some kind of sensitivity analysis: if this information was not true, how would it affect the likelihood of my hypothesis? This kind of support would make analysts aware of critical information. This critical information needs to be reliable and as such the tool allows for a differentiation between relevant and less relevant information in the top-down check for information reliability. Essentially, analysts need support in making a more explicit underpinning of the hypothesis generated. This will not only result in better judgments, but allows for better communication and evaluation by others as well.

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